BULLETIN OF THE
U.S. DEPARTMENT OF AGRICULTURE
No. 134

Contribution from the Bureau of Entomology, L. O. Howard, Chief.
October 7, 1914.

(PROFESSIONAL PAPER.)

CITRUS FRUIT INSECTS IN MEDITERRANEAN COUNTRIES.[1]

IMP. BUR.
16 FEB. 1915
ENTOM.

By H. J. QUAYLE.

THE MEDITERRANEAN FRUIT-FLY.[2]

Ceratitis capitata Wied.

OCCURRENCE.

In the Mediterranean countries the Mediterranean fruit-fly (*Ceratitis capitata* Wied.) was first recorded from Spain in 1842, from Algeria in 1859, from southern Italy in 1870, from Sicily in 1882, from Tunis in 1885, from Malta in 1893, from Egypt in 1904, and from France in 1900.[3] This chronology, however, does not necessarily represent the spread of the insect, for it may have occurred in some of the countries long before any published record appears. In addition to the countries enumerated it is also said to occur in Asiatic Turkey. In the Mediterranean vicinity it is recorded from the Azores, Madeira, and Cape Verde Islands. The writer has taken this insect at Valencia

[1] This paper is of immediate value on account of the important information it contains bearing on the subject of the need of regulating the entry of citrus and other fruits imported from Mediterranean countries to prevent the entry of the Mediterranean fruit fly into the United States. The investigations embodied in this paper were made by Prof. Quayle during the summer of 1913 as a collaborator of the Federal Horticultural Board of this Department. Prof. Quayle is an expert on citrus insects and has previously made important studies in this field in California in connection with the State experiment station. Advantage was taken of the fact that he was proposing to use his sabbatical year to make a world-wide survey of citrus insects to commission him to make a much-needed preliminary survey of the citrus and other fruit insects in Mediterranean countries, more particularly in relation to the export fruit to the United States.

The fruit-fly conditions of the principal Mediterranean citrus districts was the important subject; the report, however, includes data on other fruit insects which ought to be considered in relation to any proposed regulation of the entry of fruits from countries covered.

As having an important bearing also on the possibility of the entrance of the fruit fly with Mediterranean fruit, the investigation includes a report on harvesting and marketing conditions of citrus fruit, more particularly as to methods of picking, sorting, curing, and shipping.

This paper indicates very clearly that there is little danger of fruit-fly introduction from the lemon, which is the main citrus importation from Mediterranean countries. That there is some danger from oranges and certain other fruits at particularly favorable seasons of the year has also been clearly brought out.—C. L. MARLATT, *Chairman Federal Horticultural Board.*

[2] Italian, *Mosca della arance;* Spanish, *Mosca.*

[3] For these and other facts, including a full bibliography of *Ceratitis capitata*, see Quaintance, A. L., U. S. Dept. Agr., Bur. Ent., Circ. no. 160, 25 p., 1 fig., Oct. 5, 1912.

and Barcelona, Spain (also punctured oranges in the London markets from Murcia, Spain), at Marseille, France, throughout southern Italy and Sicily, and punctured oranges in the markets of Jerusalem, Palestine.

FOOD PLANTS AND INJURY.

In Spain, during July, 1913, the Mediterranean fruit-fly was found in peaches and oranges, but in very limited numbers. The extent of infestation in peaches, its favorite food, amounted to only a fraction of 1 per cent. It is true that most of the peaches had not yet matured, and there is no doubt that a heavier infestation occurred later in the season. Many of the pears, apples, and other fruits were examined, both in the market and in the field, but none was found infested at that

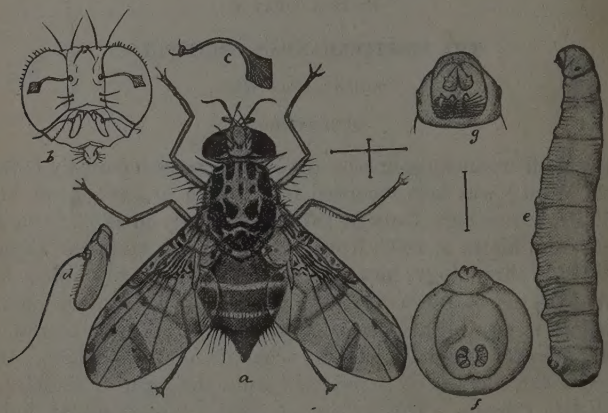


FIG. 1.—The Mediterranean fruit-fly (*Ceratitis capitata*): *a*, Adult fly; *b*, head of same from front; *c*, spatula-like hair from face of male; *d*, antenna; *e*, larva; *f*, anal segment of same; *g*, head of same. *a*, *e*, Enlarged; *b*, *g*, *f*, greatly enlarged; *c*, *d*, still more enlarged. (From Howard.)

time. Figs, which would probably be infested, were immature, as it was then in the period between the first and second crops.

During the month of March an extensive examination of oranges in the field and in packing houses was made, but at that season none was infested. It was learned that occasional complaints of infested oranges occur at the close of the shipping season during the last of June and the first of July, and again in a few of the earlier ripening fruits in October. When the section was again visited, in July, all of the crop was harvested, but scattering fruits on the trees and on the ground were common. These would be the ones likely to be infested were the fruit-fly present. After a week's examination in the groves around Valencia, only four oranges were found with the larvæ (fig. 1, *e*) of the fruit-fly. It is probable that the fly was unusually rare in 1913, because no complaint of infested fruit was recorded

from any of the late shipments, and also because of the extreme scarcity of the fly as found by the writer in other fruits, as well as in oranges.

In Sicily *Ceratitis capitata* has been reared by the writer from the following fruits: Apple, azarole, fig, Indian fig, lemon, mandarin, nectarine, orange (sweet), orange (bitter), peach, pear, and plum. Of these fruits the peach is the most severely infested. This is particularly true of the late peaches in August and September. In many places much of the fruit as it approached maturity was attacked. As a consequence most of the fruit is picked rather green and not so many of the infested fruits find their way to the markets. In some sections, however, the fruit-fly was not so abundant in the field, and it was possible to get a good percentage of sound, mature fruit. Wormy fruit was supposed not to be sold in the markets of Palermo, and this was enforced by a few 50-lire fines. After the first few days following the hatching of the larvæ infested peaches are readily distinguished, and the writer was able to get all the infested fruit necessary for experimental purposes from the Palermo markets.

All of the peaches met with in Sicily were clings and of a very firm texture. The preponderance of such a variety may be due to the fact that such fruits do not break down so readily from the attacks of the fly. Figs are also more or less infested, but to no such extent as the peach, and the loss to the figs was very little. Most of the figs are picked for drying while they are still firm, and few in this condition contained larvæ. Plums and apples were rarely infested, while a few larvæ were found in pears. The pears of Sicily are likewise of solid, firm texture, there being no Bartlett or other representatives of our better varieties. Indian figs, a very common fruit in all parts of Sicily, were not infested until September, and then only a small percentage. It was not difficult to find azaroles containing larvæ, but the greater percentage of them was sound.

Aside from a few localities where considerable injury is done to the peach, the fruit-fly is not a very destructive pest in Mediterranean countries and fruit continues to be grown successfully in spite of its presence. In these countries, too, it should be noted, the growers have little knowledge of the insects infesting their fruit, with the exception of one or two species, and they do not, as a rule, practice any measures for artificial control. The writer knows of no case where the culture of any fruit in these countries has had to be abandoned because of the destructiveness of the Mediterranean fruit-fly. While this insect was on two or three occasions, during his sojourn in the Mediterranean vicinity, served to the writer through peaches at the table, codling-moth-infested apples and pears formed a regular part of the menu in comparison. These statements are made with no purpose of minimizing the importance of the pest.

INFESTATION OF ORANGES.

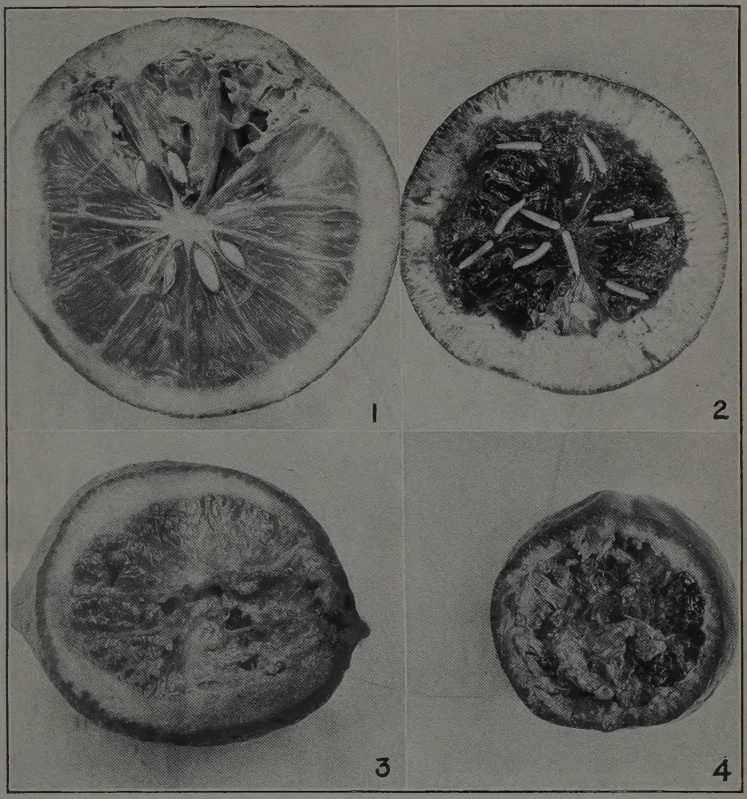
Oranges were not found infested with the fruit-fly during April and May. By the end of May oranges are almost entirely off the market in Sicily. Much orange fruit was examined during April and May, both on the Island of Sicily and on the mainland, but no infestation was found. In Calabria and at Messina oranges were seen with fruit-fly punctures from the previous season, but no larvæ were present. The eggs failed to hatch or the larvæ died immediately upon hatching without getting beyond the egg cavity. According to Dr. Martelli, entomologist at Messina, who has given considerable attention to the fruit-fly, oranges may usually be found infested by the 1st of June, but none was found with living larvæ anywhere, to the writer's knowledge, up to the second week in June of 1913.

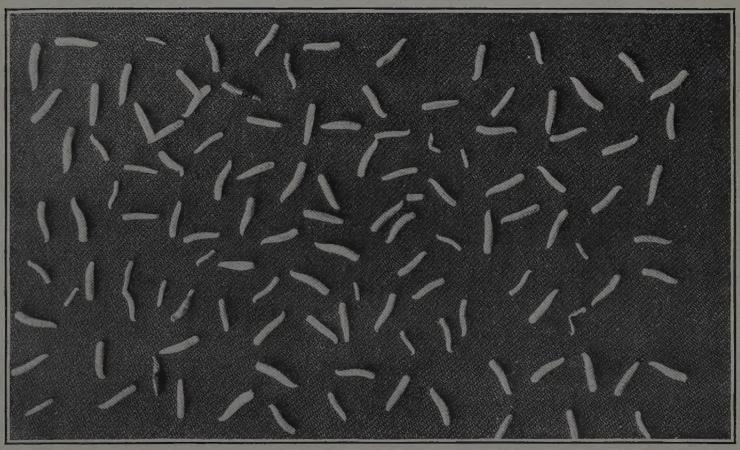
When the writer returned to Sicily on the 1st of August such ripe oranges as were still on the trees or on the ground were heavily infested with the fruit-fly (Pl. I, fig. 2). Indeed, no oranges could be found that were either not infested or did not show punctures. For some reason unaccounted for, a few oranges among an almost complete infestation will show from two or three to a dozen punctures, yet will remain sound and contain no larvæ. One orange taken late in August contained the remarkable number of 118 larvæ (Pl. I, fig. 5). These were mostly full grown, and the orange was below medium size. The pulp alone did not furnish sufficient food for such a number, so many of them had retreated to the denser rind, and it was necessary to cut this into very small pieces to disclose the larvæ, which were concealed in small burrows. This orange, before it was cut, was firm and undecayed.

The usual number found in oranges varied from 6 or 7 to 15 or 20. In peaches there were about the same number, but occasionally as many as 30 or 35. In figs usually from 3 or 4 to 8 or 10 were found, while in azaroles and plums, which are smaller, from 2 or 3 to 5 or 6 would be the usual numbers.

Both the sweet and bitter oranges were infested. The bitter orange, therefore, at least as it occurs in Sicily, is not objectionable as food to the fly. The pomelo, or grapefruit, is very rare in Sicily, as elsewhere in Europe, so that a fair test of possible infestation was not presented. A few old grapefruit, however, occurring on three or four trees that adjoined orange trees on which all the fruit was infested, showed no larvæ or punctures. Mandarins are, of course, commonly infested. (Pl. I, fig. 4.) Occasional ones, apparently remaining over from the previous year, were collected as late as August, and these were in nearly all cases infested.

The first oranges of the crop of 1913 with fruit-fly punctures were seen about the middle of September. This fruit had begun to turn yellow over a small area on one side, and the punctures were in this





5

DAMAGE TO CITRUS FRUITS BY THE MEDITERRANEAN FRUIT FLY.

Fig. 1.—Lemon infested with *Ceratitis capitata*. Fig. 2.—Orange infested with *C. capitata*. Fig. 3.—Lemon infested with *C. capitata*. Fig. 4.—Mandarin infested with *C. capitata*. Fig. 5.—118 larvae of *Ceratitis capitata* from a single orange. All from Sicily. (Original.)

yellow area. The adult flies (fig. 1, *a*) were commonly seen walking about on the fruit looking for a suitable place for oviposition. By the last of September the fly was seen in considerable numbers where the fruit was beginning to ripen. In Sicily up to the last of September it was but rarely that a tree would be found with any of the fruit showing yellow. An occasional orange would be seen at this time almost entirely yellow, but these were not mature, for they were still very sour. Punctures were common on such fruit, as well as on some others almost entirely green, and as many as a dozen punctures were often seen in a small yellow area. Possibly the punctures were partly accountable for the yellowing. The flies were seen more commonly on the trees during the morning and evening. In the rearing cages during the hot weather they remained on the ground or out of the direct sunlight during the middle of the day.

A large number of punctured oranges were examined during the last of September. Not a single one was actually found infested with the larvæ. Ninety per cent of the punctures examined either contained no eggs or larvæ, or contained eggs that had failed to hatch or larvæ that were dead. The remainder contained eggs but recently deposited, or young larvæ that had just hatched and were still within the egg cavity. The reason for the absence of eggs in many of the punctures is probably that the fly, after making the puncture, found conditions unsuitable for oviposition. The presence of shriveled eggs or dead larvæ in the egg cavity must be due to the immaturity of the fruit. In a large majority of cases the eggs had hatched; in fact, only a few unhatched eggs were found.

In immature oranges there is often a formation of gum about the puncture. Green oranges were known to have punctures, in some cases, by the presence of small globules of gum on the surface. When these oranges were taken from the tree and opened they were found to contain eggs, or larvæ that had just hatched. Very soon a yellow spot occurs about the point of puncture, and the gum upon hardening is easily removed, and probably soon falls off naturally. A hard, gummy, granular tissue also forms around the egg cavity, and it is often possible to remove this ball of brown tissue with the egg cavity intact. It was at first thought that the formation of this tissue, by furnishing an impenetrable wall around the egg cavity or by compressing the eggs and larvæ within, was the direct cause of the insect's mortality. But this hard tissue is not formed to any extent before the eggs hatch. In practically all cases where living young larvæ were found, which indicated recent oviposition, the surrounding tissue was not appreciably hardened, although the brown color began to show.

The egg cavity is situated in the spongy layer of the rind, just below the outer covering containing the oil cells. The surrounding wall of

gum seems to be formed from the outer layer, but soon extends into the spongy tissue and entirely surrounds the egg cavity. The number of larvæ found in the punctures in September was always large—from 20 to 30 or 40. Larvæ were seen closely massed together in the egg cavity, but although appearing perfectly normal they were inactive. In such cases death had occurred recently, for later they became brown and shriveled. Occasionally one or two would be seen to move slightly. In some cases two or three larvæ had made their way out of the egg cavity and penetrated a short distance into the spongy tissue. In no case, however, was the pulp reached. Why the larvæ perished within the egg cavity or soft spongy tissue is not definitely accounted for. It appears to be because of lack of air or through the action of some substance in the rind.

A large majority of the punctures in green oranges were seen to be entirely sealed by gum. The tendency of citrus fruits, or, in fact, any fruit, to exude gum to repair wounds while they are immature, is well known. The condition of the larvæ in the egg cavity—simply dying massed together as they hatched, with no evidence of any attempt to migrate—may indicate suffocation. While many larvæ occur in a single cavity, and the space is well occupied, death can hardly be accounted for through compression by growth of tissue or gum formation, because some of them, at least, could work their way out of the cavity. In cases where living larvæ were found, from 30 to 40 were seen in a single cavity with plenty of opportunity for migration.

That fruit-fly larvæ require considerable air was shown in the case of those that were transferred into a juicy lemon, where the entrance was completely closed by the posterior tip of the bodies of a half dozen or more of the larvæ. Numerous instances of the death of full-grown larvæ have been noted to take place in the exuding juices of fruit in glass jars. In peaches and other fruits, also, there are holes in the outer epidermis, made at first through oviposition and later enlarged and serving for the entrance of air.

Fruit-fly larvæ appear to live largely in decayed tissue; that is, the decay induced by them seems to precede the progress of the larvæ. It is possible that in green fruit this decay is not so readily induced. And here, again, the organisms of decay may be kept entirely out of the fruit if the entrance to the surface is effectually closed.

On September 24, 1913, 25 living young larvæ that had just hatched were taken from an egg cavity of the greenest orange found infested and placed through a hole in the rind into the pulp of the same orange. In another orange, also very green, a hole was made connecting the egg cavity with the pulp without disturbing the young larvæ in the cavity. In both cases openings were left to the surface. When the fruit was examined on October 3, partly grown larvæ were found in both of the oranges mentioned. Only a small percentage, however,

had lived, although the number was sufficient to indicate that the pulp of the orange was not too green or too acid to serve as food. These oranges were perfectly green, there being no yellow whatever on one and only a slight tinge over a small area on the other. The inability of the larvæ to reach the pulp seems, therefore, to be due to an injurious substance in the rind, to lack of air, to decay, or to all three combined.

From examination of oranges in Italy, Sicily, and Palestine, as they are maturing in the fall, there appears to be no possibility of infestation until the fruit reaches maturity, even though eggs of the fruit-fly may be deposited. The practical bearing of this fact is important in greatly limiting the season of infestation. And in the Mediterranean countries visited, cold weather appears by the time the fruit is mature and susceptible to infestation, so that the season is very short in the autumn, and most of the fruit is harvested before the return of warm weather in the spring.

APPEARANCE OF FRUIT-FLY PUNCTURES IN ORANGES.

Immediately after the adult fruit-fly has oviposited in the orange the puncture is not readily distinguishable, but it soon appears as a brown or grayish, oval-shaped area about 0.5 mm. long, with a crack or opening in the center. In green oranges the area immediately around this may be yellow. Later this area may become brown and depressed. After some time also the point of puncture is indicated by a distinct conical elevation. These elevations are conspicuous on the surface of the fruit and they may at once be diagnosed as indicating punctures of the Mediterranean fruit-fly. In older fruit these conical elevations may arise from circular depressions which are of a brownish or yellowish color. If the outer layer containing the oil cells be cut away, the egg cavity will be disclosed in the spongy tissue. After some time brown and hard granular tissue usually surrounds the egg cavity, so that the whole may be removed from the surrounding tissue as a gall. To make sure that punctures are present the egg cavity should be examined for the egg skins, shriveled eggs, or larvæ. If the orange is infested, small burrows may be traced through the spongy layer to the pulp, and the pulp itself will be decayed. Typical punctures are at once distinguished, but their character and form vary so greatly that sometimes other scars or abrasions on the fruit may be mistaken for them.[1]

INFESTATION OF LEMONS.

The only supposed instance recorded of the occurrence of *Ceratitis capitata* in lemons in Sicily is a note by Prof. Inzenga in the Annali di Agricoltura Siciliana, Volume XIV, 1884, page 101. In

[1] Since the foregoing was written the writer has examined fruit-fly conditions in the Hawaiian Islands, where they are strikingly different from those in Mediterranean countries. The most evident difference in appearance of the fruit in Hawaii is the much more copious exudation of gum.

this article Prof. Inzenga simply states that a "small worm" was observed by Profs. Alfonso and Bonafede to breed in the orange, lemon, Indian fig, and other varieties of fruit. Prof. De Stefani,[1] of the Universitate di Palermo, questions, and rightly so, the authenticity of the statement, adding as proof that in all the writings of Profs. Alfonso and Bonafede no statement occurs to the effect that *Ceratitis capitata* breeds in lemons. Prof. De Stefani further calls attention to the fact that no entomologist (excepting the questionable case above) has ever observed Ceratitis to breed in lemons in Italy; and concluded with the statement that "It is excluded absolutely that *Ceratitis capitata* lives in the lemons in Sicily." (E. da excludersi assolutamente che la *Ceratitis capitata* viva nei lemoni di Sicilia.)

Dr. G. Martelli, who has made careful studies on *Ceratitis capitata*, published an article entitled "La Mosca della arance non vive nei nostri limoni" (The orange fly does not breed in our lemons), in the Giornale di Agricoltura Meridionali, No. 9, Ann. V, 1913, Messina. In a paper read before the R. Scuola Superiore di Agricoltura at Portici in January, 1913, Dr. Martelli records experiments in attempting to transfer the eggs of *Ceratitis* into the lemons. These experiments all resulted negatively, and he concluded that the insect would not live in lemons.

During April and May an extensive examination in all the sections of Sicily was made in the field, as well as in numerous field and exporters' packing houses, with the result that no evidence of infested lemons was found. This was the season when the heaviest shipments were being made to the United States, and it was felt that a thorough examination should be made at that time. But at that season no fruit-fly larvæ appeared in any other fruit, and thus negative evidence under such circumstances would be of little value. Consequently it was proposed that the inspection be continued at a later and more favorable season, and this was at once agreed to by Mr. Marlatt, chairman of the Federal Horticultural Board. Accordingly the writer returned to the Island of Sicily, where he remained throughout August and September.

As already intimated, there was abundant evidence of the presence of *Ceratitis capitata* in other fruits at that time. Field inspection was therefore resumed in the lemon groves of Sicily during the first week in August, and during the second week there was found the first evidence of the breeding of *Ceratitis capitata* in lemons. (Pl. I, figs. 1, 3.) The infested lemons were large, overripe ones, with more or less decay, and were found on the ground. The total number found during the week was four, all taken in the same grove. Near by were many old ripe oranges severely infested with the fly. The week following 10 more infested lemons were found; most of these

[1] Intorno ad Alcuni Insetti degli Agrumi del Prof. Teodosio De Stefani, Palermo, p. 6, 1913.

were taken in this grove, but four were taken in three other places. Two out of the 10 taken during the week were on the tree, while the remainder were on the ground. It should be stated that the two taken from the tree were also partly decayed on one side. The decay in most of these lemons appeared not to be due entirely to the fruit-fly. No punctures were seen, and it is assumed that the eggs were deposited in the decayed side, or else the decay which set in later completely obliterated the punctures. One more lemon with fruit-fly larvæ was found during the fifth week, making a total of 15 infested lemons out of the thousands examined. None was found during the remaining three weeks of the inspection. None of the infested lemons would have been considered for shipment, and with three or four exceptions would not have been taken for the by-product factory. In some of the lemons, it is true, the larvæ were nearly grown, and the condition of the fruit can not be vouched for at the time of oviposition, but in others the larvæ were but partly grown, and thus the fruit had not been long infested.[1]

EXPERIMENTS WITH THE FRUIT-FLY.

Through the kindness of the Prince of Galati use was had of a neglected garden within the city of Palermo, and under a tree here was equipped an improvised laboratory. (Pl. X, fig. 5.) Three series of experiments were carried on. The first series was to determine if it is possible to transfer the larvæ of Ceratitis from other fruits into the lemon and bring them to maturity. The idea was generally held in Italy, even by the entomologists, that the lemon is too bitter or acid for the fruit-fly. The second series was to determine the possible extent of oviposition on lemons in confinement, and the third as a check on the second series and for life-history work, and to determine the extent of breeding in other fruits, as the apple, pear, peach, and orange, under the same conditions.

To summarize briefly, the first series of experiments resulted in establishing the fact that it is possible to transfer fruit-fly larvæ from a fine ripe peach to a ripe and also to a perfectly green lemon and bring them to maturity. The second series, so far as the experiments were conducted in small glass containers, resulted negatively. The third series resulted in securing oviposition and development in the peach, pear, and orange.

In the first set of experiments a small plug was cut out of the rind of the lemon, and a small cavity made in the pulp, just large enough to contain the larvæ. After the larvæ were transferred, the plug of rind was replaced, a small triangular piece first being cut out of one side of the plug for air. Aseptic methods were employed

[1] In Hawaii a perfectly sound lemon has been seen with a single specimen of *Ceratitis capitata*. In Hawaii, also ,Ceratitis punctures in lemons are very common, though actual infestation seems to be rare.

in these operations, although not with entire success, to prevent infection from molds, which gave considerable trouble. In 12 experiments 163 larvæ were transferred into lemons, and 108, or 66.2 per cent, changed to pupæ and emerged. The time spent in the lemons varied from 2 to 10 days, with an average maximum of 7.7 days.

The length of the larval period was determined as 10 to 11 days. On this basis the age of the larvæ transferred varied from 1 or 2 to 10 days. It will be noted that not all the larvæ developed, 33.8 per cent having died from one cause or another. The molds in the fruit were probably the chief factor in the mortality. The exuding juice drowned a good many that were emerging for pupation, others were dead in the fruit, and possibly some were injured in the transfer. Enough, however, emerged to show that the lemon is not an impossible food for the larvæ of *Ceratitis capitata*.

In each of 48 glass jars from 1 to 2 lemons were placed and from 6 to 22 flies liberated. These were fed with sweetened water, and lived from 3 to 26 days, the large majority, however, dying after 6 or 7 days. No infested lemons resulted from these experiments and no punctures were found. Under the same conditions peaches, pears, and oranges became infested, but with these some of the experiments also resulted negatively. Apples in three jars were not infested. In only a few cases were flies seen in copulation, and it appeared that they were too closely confined and under too unnatural conditions for free breeding.

In four large breeding boxes, where infested fruit was placed on the ground and the flies allowed to emerge, a total of 56 lemons in all stages of ripeness was placed. In 2 of these boxes the fruit was first punctured with a needle or scalpel, and in the other 2 the lemons were sound. Some of the lemons remained in these boxes for 6 weeks. Hundreds of flies emerged in each of the boxes. The lemons, when examined, were in various stages, many being decayed. No infested fruit was found, and no punctures of the fruit-fly were seen in any of the lemons.

While these experiments were not, of course, extensive and adequate enough to establish any fact on negative evidence alone, they do show that oviposition in the lemon in Italy is not at all common.

PUPATION.

Ordinarily fruit-fly larvæ go into the soil to the depth of about an inch, or otherwise seclude themselves for pupation; but this is not at all necessary, and pupation may occur anywhere in the open and direct light. The side of a packing box or any other container of fruit is thus suitable for the purpose, and the fruit-fly may be transported in this manner.

LIFE CYCLE.

No extended life-history studies were attempted or possible in the time available, but such records as were kept indicate that the life cycle of Ceratitis is completed in 22 or 23 days in Sicily in August. Out of this total, 2 or 3 days are required for the eggs to hatch, 10 or 11 days for the development of the larvæ, and 10 days for the pupal period. Since these records were made during the warmest weather they represent the minimum time for development.

OTHER INSECTS IN ORANGES AND LEMONS LIKELY TO BE MISTAKEN FOR THE MEDITERRANEAN FRUIT-FLY.

The commonest insect occurring in decayed or overripe oranges and lemons on the ground, and also occasionally on the tree, is a nitidulid beetle, *Carpophilus dimidiatus* Fab. Larvæ and adults of this beetle often occur in great numbers. Usually decay has already set in before the fruit is attacked, but if it remains on the ground for some time the beetles will bore through the rind and they themselves cause decay. The appearance of such fruit is very much like that infested by Ceratitis. The larva of Carpophilus is about the same length as that of the fruit-fly, but is easily distinguished because it is beetle-like and both ends are tipped with brown. Instead of breaking down, lemons often dry with extremely hard, firm rind, and they remain in this condition for months. Such lemons occurring on the ground are, however, frequently infested with this beetle. The beetle enters the fruit where it rests on the ground by drilling holes through the firm rind.

Another common "worm" in decayed oranges and lemons is the larva of a fly, *Lonchaea splendida* Loew. This larva is more slender and of a paler color than that of the fruit-fly, but small specimens are very likely to be mistaken for fruit-fly larvæ; hence they must be examined closely and identified by the spiracles to make sure of the species. The adult fly is smaller than Ceratitis and is of a metallic blue color.

Larvæ of Drosophila also frequently occur in decayed oranges and lemons, but, except in possible cases of very small specimens, they are easily distinguished from the more robust and yellowish white Ceratitis larvæ. Of all the "worms" infesting oranges and lemons, Ceratitis larvæ are the most sluggish and slow moving, so that with a little experience they may be distinguished by their movements.

THE BLACK SCALE.[1]

Saissetia oleae Bern.

DISTRIBUTION AND INJURY.

The black scale is generally distributed throughout the Mediterranean citrus sections. (Fig. 2.) It varies in numbers from an occasional scale to numerous specimens forming a complete incrustation on the twigs and branches, and in injury from an insect of no commercial importance to one doing much damage through the quantity of sooty-mold fungus found on the trees and fruit.

In the most important orange section of the Mediterranean countries, that of Valencia, Spain, the black scale is, according to our standards of judging, entitled to rank first among the citrus fruit pests. This statement is at least true for the years 1912 and 1913. In all of the scores of packing houses visited during the month of March, 1913,

FIG. 2.—Distribution of insect enemies of citrus fruits in Mediterranean countries. (Original.)

from a half dozen to 15 or 20 women were seen washing fruit to remove the sooty-mold fungus occurring as a result of black-scale infestation. In some cases the sooty mold was due to the mealy bug (*Pseudococcus citri*), but infection from this source would amount to only a small percentage of the total. During July, 1913, when the section was again visited, numerous young were seen on the leaves, which, barring a heavy mortality later, would furnish the same conditions for the season following. In numerous groves around Burriana, Spain, the sooty-mold fungus was seen to form a complete coating over all the upper surface of the leaves, branches, and fruit, and such a severe incrustation of scales occurred as actually to kill many of the smaller twigs, and in some cases even the larger branches.

The greatest injury from the black scale was seen in the "Plana," or level district opening to the sea north of Valencia, and centering around Burriana. The conditions here are much the same as in the

[1] Spanish, *Escania negra;* Italian, *Cocciniglia dell' olivo.*

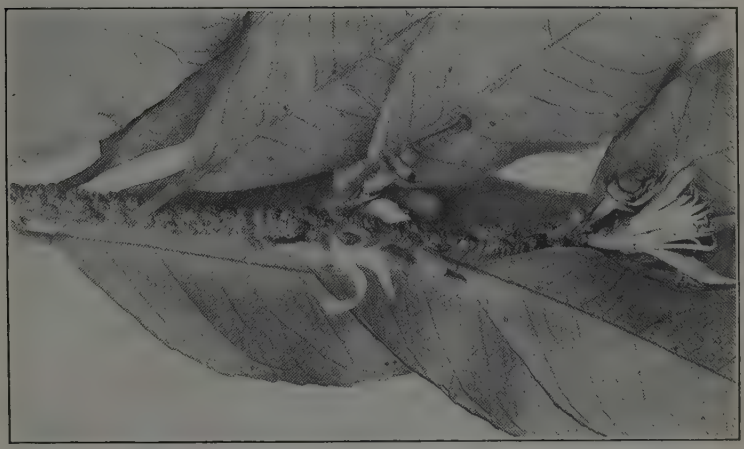


FIG. 1.—THE BLACK SCALE (SAISSETIA OLEAE) ON LEMON TWIG, SICILY. (ORIGINAL.)

FIG. 2.—A COMMON CITRUS SCALE (PARLATORIA ZIZYPHUS) ON A LEMON LEAF, SICILY. (ORIGINAL.)

SOME SCALE INSECT ENEMIES OF CITRUS FRUITS IN SICILY.

coast counties in southern California, where the same scale is most important as a pest. The "Ribera," or section south of Valencia, is hilly and rolling and is separated from the sea by hills and mountains. The direct sea influence is, therefore, not so pronounced, and the black scale is not so generally injurious. The influence of the sea consists in moderating the effect of the summer heat, which, if too intense, results in a wholesale mortality of the young scales, in which stage the scale is largely found during the summer months.

The black scale is also more or less abundant in localities farther south, as Murcia, Malaga, and Seville. But in these sections, which are still farther removed from the sea, the black scale is not so important a pest as is *Crysomphalus dictyospermi*.

The washing of oranges in Spain consists in rubbing each individual fruit, first in wet, and then in dry sawdust, the latter both to hasten the drying and to complete the cleaning. It is not a bad system so far as results are concerned, and, with the low price of labor (20 cents a day for women), the expense is no greater and probably much less than with the use of machinery as with us. The sawdust method, however, leaves more traces of the mold in the small depressions of the fruit than does our machine with brushes. When attention was called by the writer to the absence of any aseptic agent in the water used in dampening the sawdust—and it is used over and over again—the reply was evoked that there is no better disinfecting agent than ordinary sea water. But the writer was not sure that sea water was being used, and he was very certain it was not in many places. The amount of fruit receiving the sawdust treatment varied from 25 per cent to more than 90 per cent in most of the packing houses visited.

The washing of the fruit, according to Spanish standards, is regarded simply as one of the regular practices of the packing house, and is not an expense generally attributed to the black scale or any other insect. In fact, no one was seen in Spain who considered that the sooty-mold fungus [1] was in any way related to the black scale. It was for this reason that the statement appears at the beginning of this discussion that the black scale is considered by the writer to be the most important pest in the Valencia section, "according to our standards." According to Spanish standards it is no pest at all, chiefly because the insect and its important effect, the sooty-mold fungus, are not generally considered as in any way related.

But the injury by the black scale in the Valencia section is not due entirely to the presence of mold on the fruit. When such severe infestations occur as were frequently seen, the tree itself suffers. Small twigs are killed, and the coating of mold over the leaf, branch, and fruit not only interferes with the functions of the tree, but the fruit itself is deficient in sweetness and flavor.

[1] Spanish, *Negrilla*.

In Sicily the black scale was seen in great abundance in several places, but these places usually consisted of but a small area, or even but a few trees. (Pl. II, fig. 1.) It is found in scattering numbers throughout the citrus area, but with the exception of a few cases of dirty fruit which have been seen, coming from limited areas, as noted above, the black scale is not a serious pest in this, the most important lemon section of the Mediterranean. It is the writer's opinion that, above all other factors, the absence of the scale in serious numbers in Sicily is due to the sirocco, which frequently prevails there during the summer and fall. This is a burning hot, dry wind from the African deserts. It is only necessary to experience one of these siroccos, which usually lasts about three days, to conclude what effect it would have on insects not well adapted to withstand heat and dryness. Opportunity was afforded for judging the effects of a sirocco on young black scale in Sicily, with the result that between 95 and 100 per cent were seen to be killed. The same effect of hot weather has been observed by Mr. C. L. Marlatt,[1] Mr. R. S. Woglum,[2] and the writer[3] in California.

SEASONAL HISTORY.

So far as could be observed the black scale has very much the same life and seasonal history in Mediterranean countries as it has in California. The majority of the young appear in June and July. These settle almost entirely upon the leaves or on the tender twigs. It is during this period that high temperatures are likely to cause a heavy mortality. Later in the fall the young that still survive migrate to their permanent abode on the twigs and branches, and pass the winter as partly grown insects. During this season growth is very slow, but with the resumption of warm weather in the spring it proceeds rapidly. By May and June oviposition occurs, and from 2,000 to 3,000 eggs are deposited by a single female during a period of from 30 to 60 days. While the majority thus mature in the spring and require 8 or 10 months for development, others, that have all the heat of summer, will mature in 4 or 5 months, and thus some scales will be found in all stages at all seasons.

NATURAL ENEMIES.

The most important natural enemy of the black scale in most sections where it occurs is *Scutellista cyanea* Motch. It was a surprise, however, to find that this parasite occurred in less numbers in

[1] Marlatt, C. L. Insect control in California. U. S. Dept. Agr. Yearbook for 1896, p. 217–236, Pl. V, 1897. See p. 218.

[2] Woglum, R. S. Fumigation investigations in California. U. S. Dept. Agr., Bur. Ent., Bul. 79, 73 p., 28 figs., June 11, 1909. See p. 12.

[3] Quayle, H. J. The black scale. Cal. Univ. Coll. Agr. Expt. Sta. Bul. 223, p. 151–200, 24 figs., 8 pl., July, 1911. See p. 165.

many of the Mediterranean countries than it does in California. In those countries where no artificial control is practiced it was thought that all natural enemies would be more abundant. On the other hand, no place was seen where the numbers equaled those of the California citrus belt, with a possible exception in the case of *Ceroplastes rusci* L. on the fig, in a few places in Sicily. In Spain, where the black scale was so abundant on citrus trees, very few were attacked by Scutellista. Where counts were made the maximum did not exceed 20 per cent, while hundreds of scales were examined in many places with no evidence at all of parasitism. Scutellista, like most insects, has its periods of increase and decrease, and the year 1913 may have been at the end of a depression. But during years when it occurs in fewest numbers in southern California it is much more abundant than it was observed to be in Spain in 1913. In Sicily, also, Scutellista was not seen in large numbers anywhere on the black scale on citrus trees.

Aside from Scutellista the only other enemies of any importance noted were two coccinellids, *Chilocorus bipustulatus* L. and *Exochomus 4-pustulatus* L. These, however, are general feeders, and were seen to occur more abundantly on trees infested with *Chrysomphalus dictyospermi*, *Parlatoria zizyphus*, and *Lepidosaphes beckii* than on those infested by the black scale. *Rhizobius ventralis* Er., the most important coccinellid on the black scale in California, was not seen in Spain or Italy.

CHRYSOMPHALUS DICTYOSPERMI Morg.[1]

DISTRIBUTION AND INJURY.

Chrysomphalus dictyospermi is found in most of the citrus sections of Spain. It was commonly observed at Malaga, Seville, Murcia, and Valencia. In the Valencia section it was most injurious at Piaporto, Picaña, and Piug. At each of these places fumigation, introduced by Mr. R. S. Woglum, of this bureau, was seen in practice. Here the scale occasioned severe injury to the trees, mostly through the dropping of the leaves. While it was observed in scattering numbers around Burriana, nowhere was it seen to do any important injury. Why it does not occur there in greater numbers is not known. It was thought that parasites must be at work, but practically no evidence of parasites was seen, so far as examination was made during the month of March. That this scale was not recently introduced in the Burriana district appears to be indicated from the fact that it occurs there over such a large area. This scale was also seen occasionally around Alcira in the "Ribera."

[1] Spanish, *Piojo rojo;* Valenciana, *Poll roig;* in Murcia and provinces of Andalucia, *Cochinella rojo;* Italian, *Cocciniglia bianco-rosso;* Sicilian, *Bianca-russa.*

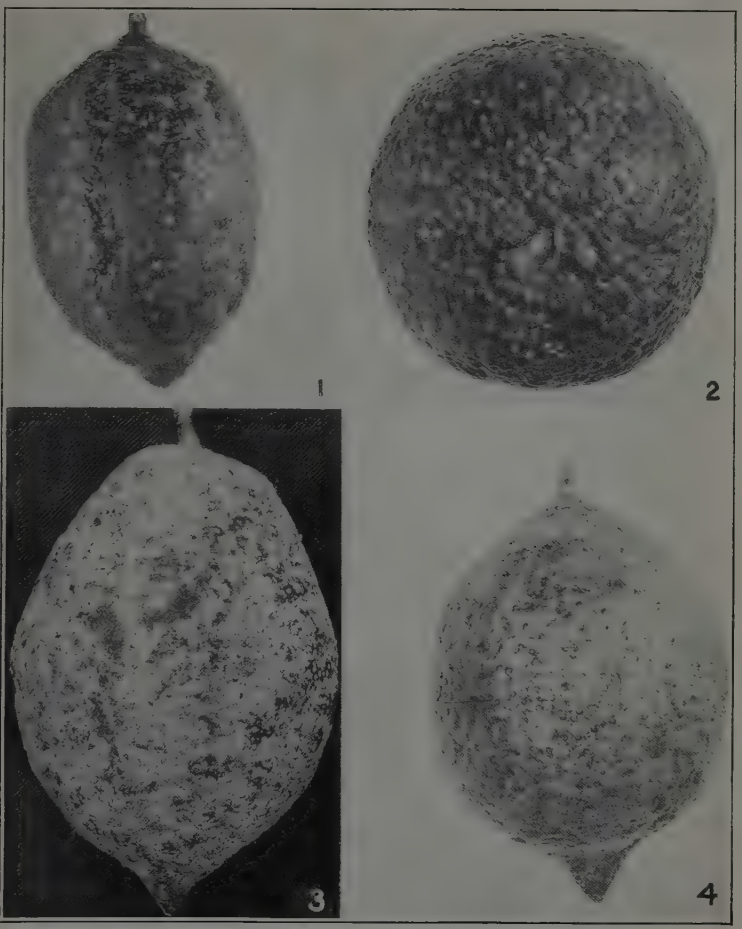
If this scale occurred widely over the Valencia section in such numbers as at Piaporto, Picaña, and Piug, it would, of course, outrank the black scale in destructiveness. At the points mentioned it is the most serious of all the scales because of its damage to the tree, as well as its effect on the market value of the fruit. It occurs also in injurious numbers farther south, as at Murcia, Malaga, and Seville. It is very commonly seen on the fruit in the markets in these sections, and the trees in many places show the effect of the scales. Even in the famous Patio de los Naranjos (Court of Oranges) of the mosque at Cordova and of the cathedral at Seville the trees are having a hard struggle to exist on account of the severe infestation by this scale. Taking the entire citrus area of Spain this scale may be the most important, but in the important commercial section of Valencia, where 90 per cent of the crop is produced, it is first only in a few small areas.

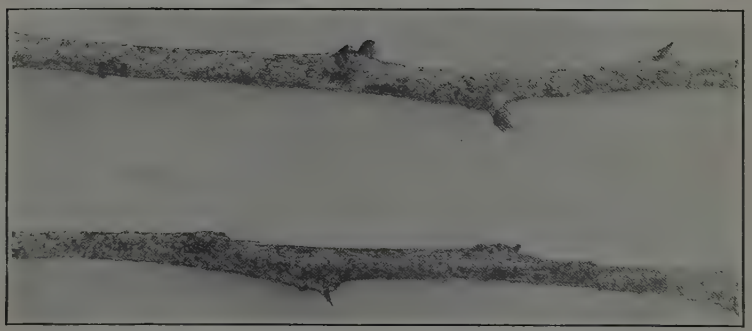
In the citrus belt along the French and Italian Riviera this species was seen at San Remo and Porto Maurizio; at the former place in destructive numbers on a few small trees. In Sicily it occurs at Catania, Messina, and Palermo. (Pl. III, fig. 4; Pl. IV, figs. 1 and 2.) At Messina it is found in several places around the city and does considerable injury. Its first recorded appearance on the island, four or five years ago, was at this place. At Catania it is more or less widely distributed, while at Palermo it is still limited to a few small areas, but it is destructive as far as its spread has occurred.

LIFE HISTORY AND HABITS.

This species, somewhat like the yellow scale (*Chrysomphalus aurantii* Mask., var. *citrinus* Coq.), attacks the leaves and fruit largely. These will be found heavily infested and often there will be but a few on the twigs and branches. This habit of avoiding the twigs and branches is not so complete as with the yellow scale, but is distinctly more pronounced than with the California red scale (*Chrysomphalus aurantii* Mask.). In severe infestations, of course, and where the leaves have fallen, *C. dictyospermi* will be found in considerable numbers on the twigs. Because the twigs and branches are not so severely infested the injury is neither so great nor so rapid as is the case with *C. aurantii*. But the dropping of the leaves greatly injures the tree temporarily and new leaves scarcely grow out until they in turn are attacked.

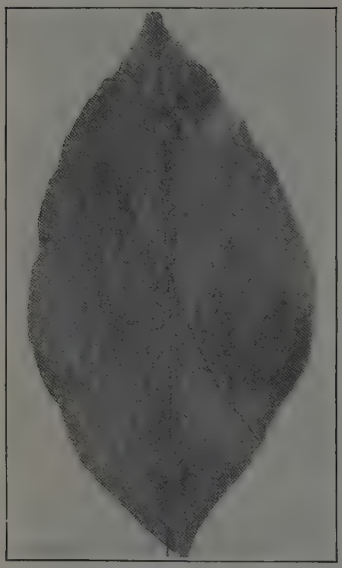
While the life history of this species has not been worked out in detail, it is probably very similar to that of *C. aurantii*. The latter species requires two and one-half to four months for its development. There would thus be between three and four, possibly four, full generations in a year.



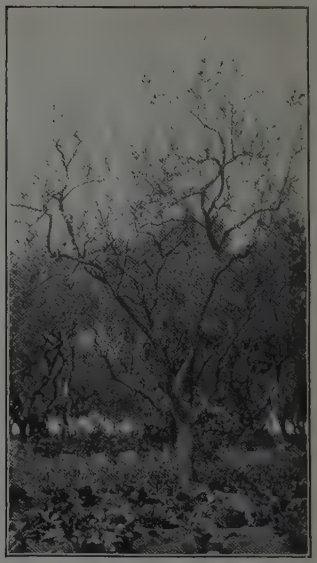


SOME SCALE INSECT ENEMIES TO CITRUS FRUITS IN SPAIN AND ITALY.

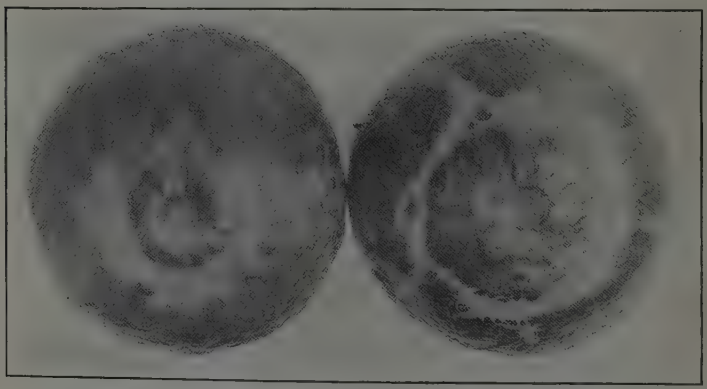
Fig. 1.—Lemon distorted by the oleander scale, *Aspidiotus hederae;* Italy. Fig. 2.—An orange infested with a common citrus scale, *Parlatoria zizyphus;* Spain. Fig. 3.—Lemon incrusted with *Aspidiotus hederae;* Sicily. Fig. 4.—Lemon infested with *Chrysomphalus dictyospermi;* Sicily. Fig. 5.—*Parlatoria zizyphus* on lemon twigs, Sicily. (Original.)



CHRYSOMPHALUS DICTYOSPERMI ON ORANGE LEAF, SICILY. (ORIGINAL.)



LEMON TREE PARTIALLY KILLED BY CHRYSOMPHALUS DICTYOSPERMI. (ORIGINAL.)



SCARS RESULTING FROM FEEDING OF THRIPS, PROBABLY HELIOTHRIPS FASCIATUS. (ORIGINAL.)

INSECT ENEMIES OF CITRUS FRUITS IN SICILY.

NATURAL ENEMIES.

The most abundant parasite of this scale is a species of Aphelinus.[1] Two or three species of Coccinellidæ have also been seen feeding on the scale. These are the same species as those already given for the black scale.

THE PURPLE SCALE.[2]

Lepidosaphes beckii Newm.

DISTRIBUTION AND INJURY.

The purple scale was seen in most of the citrus sections of Spain and Italy. It is found very generally in the Valencia orange section and in the Sicilian lemon section. Not infrequently the numbers are sufficient to do injury to the trees. This consists of the killing of a few branches, or a portion of one side of the tree. (Pl. V, fig. 1.) The scale is also more or less common on the fruit. It occurs in many places in Sicily in only scattering numbers, and in small areas, or, on a few trees, in large numbers. This is about the status of the scale in California and Florida and the Valencia section of Spain, but on the island of Sicily it is less injurious than in any of these three localities.

LIFE HISTORY.

The purple scale deposits from 40 to 80 eggs, which are well inclosed by the scale covering above and a lighter, cottony covering beneath. The eggs hatch in 15 to 20 days in summer. Most eggs and young will be found in the spring—May and June—and another large batch in August and September. At all other seasons eggs will be found, but usually in less numbers. The period of development from hatching to egg-laying ranges from one and one-half months in summer to three months in winter.

NATURAL ENEMIES.

The purple scale has been considered a pest of little economic importance in Mediterranean countries, and this has been accounted for through the efficient work of parasites. The writer takes exception to both of these counts. Just as severe injury has been seen from this scale in Spain as in California or Florida. And further, what natural enemies are keeping it in check? Hitherto, so far as known, no internal parasite has been reported from the purple scale in Sicily. Dr. Martelli was informed by the writer that he had seen evidence of *Aspidiotiphagus citrinus* attacking the purple scale, but the observation was questioned on the ground that the scale was *Lepidosaphes ulmi* and not *L. beckii*. Of course, the parasitized scales were not positively identified at the time. Later *Aspidiotiphagus citrinus*

[1] This species appears to be *A. diaspidis*, but its identity, according to Prof. Silvestri, of Portici, is somewhat questionable.

[2] Spanish, *Serpeta;* Italian, *Pidocchio a virgola;* Sicilian, *Pidocchiu.*

Craw was reared from scales on citrus trees, and those scales from which they emerged were positively identified, as was expected, as *L. beckii*. The record, therefore, stands. Dr. Leonardi, of Portici, a specialist on the Coccidæ, stated that he had seen some evidence of a parasite on the purple scale, but he had not as yet studied it and did not know the species. When the entomologists of Italy know so little about the parasite, and when it was only very rarely found by the writer, it certainly can not be counted as very effective in checking the scale. The only other enemies of this scale seen in Sicily and Spain were coccinellid beetles, and while these are more effective than *A. citrinus*, they have not been seen in large numbers, and are not accountable for keeping the scale in check.

Places have been seen in Sicily which were very free from the purple scale, but according to the growers the scale had been present there in considerable numbers several years ago, and disappeared. Because of the meager knowledge of scales and the confusion of names by most Sicilian growers, the foregoing may or may not be true. It is, however, altogether probable. (For a discussion of climatic influences, see under Meteorological data, pp. 34–35.)

THE LONG SCALE.[1]

Lepidosaphes gloverii Pack.

DISTRIBUTION AND INJURY.

The long scale, so far as observed by the writer, is limited to Spain. In that country it is particularly destructive in some sections. It is frequently associated with the purple scale, as in the Valencia section. In some cases it was more abundant than the purple. Trees most injured by this scale were seen near Burriana. (Pl. V, fig. 1.) The long scale also occurs in Florida, from which place it was first described. It has been reported from two counties in California, though it has never spread and is of no consequence as a pest there. It is distinguished from the purple scale in being much more slender, and the pygidial differences are also distinct.

PARLATORIA ZIZYPHUS Lucas.[2]

DISTRIBUTION AND INJURY.

Parlatoria zizyphus is the commonest of all the scales occurring on the lemon tree in Sicily. (Pl. II, fig. 2; Pl. III, fig. 5.) It is also found in most of the orange sections of Spain. (Pl. III, fig. 2.) In the Valencia section it was most abundant in the "Ribera" in the vicinity of Alcira. This scale ranges in abundance from a few scattering scales to a heavy incrustation on the leaves, twigs, and fruit. It

[1] Spanish, *Serpita larga*.

[2] Italian common name, *Pidocchio nero*; Sicilian, *Pidocchiu niuru*; Spanish (Valencians), *Poll nègre*.

has been noted in several instances to cause a heavy dropping of the leaves, and it is one of the commonest scales occurring on the fruit in the markets. This may be partly because it adheres so firmly to the fruit and is not easily removed by rubbing. While it occurs abundantly in Sicily it is not extremely injurious to the tree, nor does it distort the fruit as does *Aspidiotus hederae*.

NATURAL ENEMIES.

This scale is especially free from parasites. On one occasion *Aspidiotiphagus citrinus* was obtained from material infested by *zizyphus*, but it can not be positively stated that there were not a few purple scales among the material, so the record remains doubtful.

THE OLEANDER SCALE.

Aspidiotus hederae Vall.[1]

DISTRIBUTION AND INJURY.

The cosmopolitan and omnivorous oleander scale is found throughout Spain and Italy and is an important pest on ripe lemons in the latter country during the spring and early summer. (Pl. III, figs. 1 and 2.) It was also observed on oranges in Spain, but is less injurious on oranges there than on lemons in Italy. In California the same scale occurs occasionally on old over-ripe oranges and lemons, but is of no commercial importance. In May and June it is really a pest of much economic importance in Italy. If such infestation occurred in California, it would certainly mean fumigation. As much as 90 per cent of the fruit in some of the by-product factories has been seen infested with this scale. Most of such fruit was brought there because of it.

The oleander scale very seriously distorts the growth of the lemon in Italy. (Pl. III, fig. 1.) Where the scale occurs there will be a depression, so that the fruit has a rough and uneven appearance and when numerous it becomes badly misshapen and distorted. The scale also delays the coloring of the lemon, and such fruit can be distinguished at a long distance by its blotches of yellow and green. While the inferior fruit caused by the scale is considerable in Italy, it is not a complete loss because it is acceptable for the by-product factory. On the Amalfi coast, where fruit of the finest texture is produced, it would seem that spraying, at a time when the young first appear, would in many cases be profitable.

NATURAL ENEMIES.

A species of Aphelinus is the commonest parasite on this scale in Italy. On host plants other than Citrus this parasite was sometimes seen in very large numbers. *Aspidiotiphagus citrinus* has also been taken from *A. hederae*.

---

[1] Italian, *Bianca;* Sicilian, *Bianca o rugna.*

THE COTTONY CUSHION SCALE.

Icerya purchasi Mask.

DISTRIBUTION AND INJURY.

The cottony cushion scale was observed at Acireale, Messina, and Bagheria in Sicily. It was not seen elsewhere in Italy, except at Portici, and was not observed anywhere in Spain. It is of recent introduction in Sicily (five or six years ago) and is supposed to have come from North America or Portugal. A severe infestation occurred at the places mentioned in Sicily as observed in April. Several trees were killed and cut down at Bagheria. (Pl. V, fig. 2.) *Novius cardinalis* was seen at work at Messina and Acireale, but after persistent search none could be found at Bagheria despite the fact that the beetle had been liberated by Dr. Savastano in February. Dr. Savastano was informed of this fact, and another colony was promptly liberated. When the place was again visited in August it was gratifying to see that apparently the entire infestation was completely checked by the work of the beetle. The owner of the grove, who in May despaired of saving any of the trees, in August was elated and believed it little short of miraculous that he could be freed of the pest in such a short time. This infestation was so completely cleaned up that Novius had disappeared for lack of food, and no trace of the beetles could be found in August. These same conditions have been observed in California; the beetles, upon eating all of the scales by midsummer, would themselves disappear, reappearing, however, in the following spring. The few young scales that escaped the beetle the year previous would multiply to such an extent that a heavy infestation occurred by the following spring and would thus furnish food for the returning beetles wherever they came from. These circumstances were observed for four successive seasons in a particular grove in California, where the trees were finally cut back. It is hoped that these same circumstances will not prevail at Bagheria.

LIFE HISTORY.

From 500 to 800 eggs are deposited in the large fluted cottony mass which is secreted for this purpose. The eggs hatch in from 10 days to 3 weeks, depending upon the temperature. The young larvæ settle on the leaves and tender twigs largely, but later nearly all those on the leaves migrate to the twigs and branches, adults being found even on the tree trunk. The time required for development varies considerably under the same conditions and may range from three to four or five months. The great majority of eggs and young appear during May and June.

FIG. 1.—ORANGE TREES PARTIALLY KILLED BY THE PURPLE SCALE (LEPIDOSAPHES GLOVERI) AND THE LONG SCALE (LEPIDOSAPHES BECKII) AT BURRIANA, SPAIN. (ORIGINAL.)

FIG. 2.—LEMON TREES KILLED BY THE COTTONY CUSHION SCALE (ICERYA PURCHASI) AT BAGHERIA, SICILY. (ORIGINAL.)

SCALE INSECT ENEMIES OF CITRUS FRUITS IN THE MEDITERRANEAN.

FIG. 1.—THE MEALY BUG (PSEUDOCOCCUS CITRI) ON ORANGES, SICILY. (ORIGINAL.)

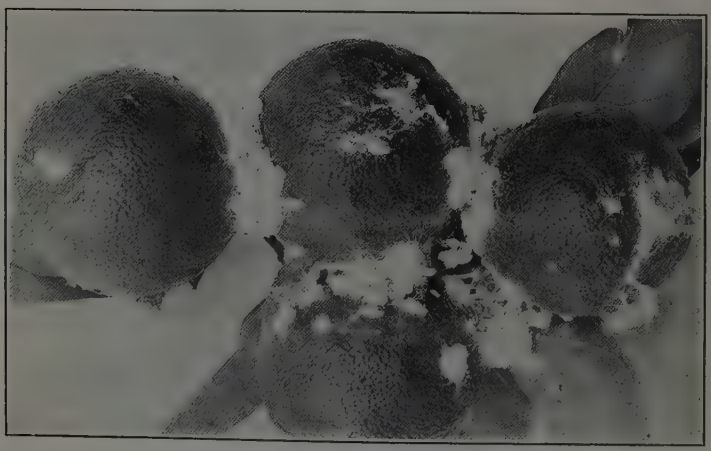


FIG. 2.—LEMONS WITH SEVERE INFESTATION OF MEALY BUG (P. CITRI), ACIREALE, SICILY. (ORIGINAL.)

DAMAGE TO CITRUS FRUITS BY THE MEALY BUG.

NATURAL ENEMIES.

The one important natural enemy of this scale in Italy, as elsewhere, is the Australian ladybird, *Novius cardinalis* Muls. This beetle, as already intimated, has been introduced into all the known colonies of the scale in Sicily. The beetle has also been distributed with success in Palestine.

Cryptochaetum icerya Will., a dipterous parasite, is the second most important enemy of the cottony cushion scale in some of the countries where it occurs, but it was not taken by the writer in Sicily. It is a small fly of a metallic green color, the larva of which lives within the scale.

THE CITRUS MEALY BUG.[1]

Pseudococcus citri Risso.

DISTRIBUTION AND INJURY.

The citrus mealy bug is found in greater or less numbers in nearly all parts of the citrus sections of Spain and Italy. It frequently occurs in serious numbers, and masses of the insects, with their cottony secretion and also much sooty-mold fungus, will be found on the leaves and fruit. In Sicily during the season of 1913 the writer unhesitatingly places the mealy bug at the head of all the citrus insect pests. *Chrysomphalus dictyospermi* is serious enough in several places, but the area involved is small as compared with that seriously infested with the mealy bug. The scale is also more amenable to treatment. The worst infestations of the mealy bug occurred along the east coast at Catania, Acireale, and Messina, and several intermediate points, though bad infestations were also seen at several points on the north coast. In many places the numbers were so great that the masses of cotton extended for an inch or two below the fruit. (Pl. VI, figs. 1 and 2.) Many of the lemons fell from the trees, others were stunted in growth, and a heavy dropping of the leaves occurred. The fallen fruit and leaves, with the insects and cotton still on them, gave the ground a distinctly whitish appearance.

Infestations of the mealy bug in Sicily in 1913 were just as severe and much more extensive than were those in the Ventura and San Diego sections in California a few years ago. Even outside of these extremely severe infestations, the insect was generally distributed and much more abundant throughout the entire citrus area in Sicily than was ever seen in California outside of the two sections mentioned.[2]

[1] Spanish (Valenciana), *Cotonet;* Italian, *Cocciniglia farinosa degli agrumi;* Sicilian, *Cuttunedda.*

[2] The writer may be pardoned for making frequent comparisons between the Mediterranean citrus sections and that of California, but this is done for three reasons: First, people can best judge of conditions in foreign countries in terms of their own conditions; second, California is most like the Mediterranean citrus region; third, the writer is acquainted with citrus conditions in California.

It was stated by many people that the mealy bug was unusually abundant on the island in 1913.

LIFE HISTORY.

The mealy bug lays 300 or 400 eggs in the cottony mass that is secreted for the purpose, and these hatch in from 10 days to three weeks, according to the season. The development ranges from one month in summer to three in winter.

NATURAL ENEMIES.

The natural enemies of *P. citri* in Sicily are varied and numerous. The writer has found feeding on or attacking this insect one species of Hemiptera, two of Neuroptera, two of Coleoptera, two of Diptera, and six or seven of Hymenoptera. Of these, probably the most important is one of the species of Diptera. Two or three species of Hymenoptera were also very common, as well as one of the coccinellids.[1]

In spite of all these enemies the mealy bug was the worst citrus pest in Sicily in 1913. The increase and decrease of this insect there, however, may be very greatly influenced by the attacks of all these enemies.

PRAYS CITRI Millier.[2]

DISTRIBUTION AND INJURY.

Prays citri is the name of a small moth the larva of which often does serious injury to the blossoms of the orange and lemon. It is found in Sicily, in the Provinces of Calabria and Campania, and probably in other less important citrus sections of Italy. It was seen to be particularly abundant in the vicinity of Messina in August, 1913, and a large percentage of the blossoms and newly formed fruit was destroyed. It occurs from April to November, but is especially destructive to the blossoms of the forced *verdelli* crop, which occurs in midsummer. The injury is caused by the larvæ eating into all the flower organs—stamens, pistils, petals, and ovule.

LIFE HISTORY.

The eggs are deposited apparently upon the calices or peduncle of the flower, usually just prior to opening. The larvæ upon hatching bore through the inclosing parts to the organs within. Flowers thus attacked will have holes in the calyx, parts eaten out of the stamen, or burrows made into the pistil and ovule. Pupation usually occurs within the flower, but also in protected places on the leaves or forks of the twigs and branches.

[1] These different species of parasitic and predaceous enemies of the mealy bug in Sicily may be treated in more detail in a later paper.

[2] Italian common name, *Tignola degli agrumi.*

RED SPIDERS.

One species of red spider was seen in all the citrus sections of Spain and Italy. With a few exceptions, however, the numbers were not sufficient to do any great injury. Over small areas, particularly along the roadside where there was considerable dust on the trees, many of the leaves had the characteristic light-colored mitelike areas. Not infrequently, too, the lemons would be scarred around the depression formed by the nipple at the calyx end, this situation being the most favorable feeding place on the fruit.

This species is identified by the Italian entomologists as *Tetranychus telarius*. What we have been calling *telarius* in this country has recently been made synonymous with *T. bimaculatus* Harv. The habits of *bimaculatus* in the citrus belt of California are very different from those of *telarius* in Spain and Italy. *Bimaculatus* has been observed to infest severely other food plants growing in the midst of citrus trees, both in California and Florida, without attacking the citrus trees at all. *Bimaculatus* on beans, violets, and a long list of other plants, feeds generally over the entire surface. *Telarius* in Spain and Italy feeds in restricted areas precisely as does *T. sexmaculatus* Riley on citrus trees. But red forms of *telarius* are common in Mediterranean countries, while in California all that have been observed of *sexmaculatus* are pale colored. The writer is not, however, necessarily assuming that *sexmaculatus* and *telarius* are synonyms, though their feeding habits are similar. He is, however, of the opinion that, judging from their difference in feeding habits, our *bimaculatus* and the European *telarius* are not synonymous if the Mediterranean citrus species is properly identified as *telarius*.

Another species which is flat and scalelike, probably a species of Tenuipalpus, was occasionally met with on citrus foliage in Sicily.

THRIPS.

A species of thrips, said to be *Heliothrips fasciatus* Perg., occasionally does some injury to the orange as shown by the marred fruit. (Pl. IV, fig. 3.) But thrips scars on the fruit in Spain and Italy are rare, so that the insect is of little economic importance. Around Jaffa, however, a species of thrips sometimes does considerable injury, and spraying has been necessary.

THE CONTROL OF CITRUS FRUIT INSECTS IN MEDITERRANEAN COUNTRIES.

With the exception of a little fumigation in Spain for the control of *Chrysomphalus dictyospermi*, and limited spraying in Sicily for the same insect, practically no remedial measures are employed for the control of citrus fruit insects in the countries bordering on the Mediterranean. This fact might be taken to mean that the pests there are

of little economic importance because of their natural enemies, or for some other reason. But the lack of preventive measures in those countries as compared with California and Florida is largely a question of standards.

The black scale is as serious a pest in Spain as it is in California. A large share of the million dollars a year spent in California for the control of citrus pests is counted against this insect. The black scale is not, however, as serious a pest in Sicily as it is in California and Spain. The purple scale injures trees and mars fruit in Spain and Italy as it does in California and Florida. The long scale is more injurious in Spain than it is in Florida, so far as the writer's observations have extended in Florida. This scale is not reported from Italy. While it is recorded from one or two small sections in California, it is of no consequence as a pest. *Parlatoria zizyphus* not infrequently causes a heavy dropping of the leaves, and also attacks the fruit both in Spain and Italy. It is not a general pest in the groves of California or Florida. It is often taken, however, on lemons in the markets of the eastern States, having been imported from Italy. *Aspidiotus hederae* is a more serious pest on ripe lemons in Italy than it is anywhere in the United States. The mealy bug, *Pseudococcus citri*, ranks just as high, if not higher, as a pest in Spain and Sicily than it does in California. The citrus white-fly, the most serious of the Florida citrus pests, does not occur in the Mediterranean region.

Nothing in the way of artificial control is practiced against any of the foregoing insects in any of the Mediterranean countries. One or two cases were met with in Spain where the grower had tried some patent concoctions on a few trees. Pruning, however, may come in the category of control for insects in those countries more than it does with us, as the following dialogue may illustrate: "What do you do for the scales when they actually kill the twigs and branches as seen on the trees before us?" "We cut out the twigs and branches." Cutting out dead twigs and branches is, of course, a part of the pruning process, and not infrequently these dead parts are due to one of the foregoing insects. If the fruit is infested with the sooty-mold fungus, it is washed in sawdust, but the cause is not taken into consideration. If scales are present on the fruit, such fruit is placed in an inferior grade, or it is consigned to the by-product factory.

In the case of *Chrysomphalus dictyospermi*, however, a start in control work is really being made both in Spain and in Italy. This is no doubt due to the fact that this scale causes more complete injury to the trees—indeed, practically kills them. As before stated, fumigation was seen practiced in Spain last year at Piaporto, Picaña, and Piug in the Valencia section. Possibly it is practiced also in other places, but evidence was not seen elsewhere at the time of the writer's

visit. Mr. R. S. Woglum, of this bureau, introduced fumigation in Spain in 1910, and it is being carried on in accordance with modern California methods. (Pl. X, fig. 4.) The cost as figured from a definite number of trees amounted to 1.10 pesetas, or about 20 cents per tree. In actual practice growers state that the cost averages from 25 to 30 cents a tree, which is about the same as that of California for trees of the same size. There are no large trees in the Valencia section and there are no seedlings.

Advocated by Dr. L. Savastano,[1] the well-known pathologist, director of the experiment station at Acireale, the use of lime-sulphur is becoming popular for the control of *C. dictyospermi* in Sicily. Fumigation is out of the question in most parts of Italy where citrus trees are planted solidly because of the nearness of the trees. Spraying, therefore, is the only artificial measure that may be employed. The lime-sulphur spray is intended to kill the young largely. It is applied in June and again in August or the first part of September. The strength used is 5 per cent of lime-sulphur of 1.25 gravity (29° Baumé). This is for summer use when high temperatures may cause burning if used stronger. During the winter it is used at a strength of 8 per cent and, if the infestation is severe and many of the leaves off, as high as 10 per cent. Lime-sulphur at the strength mentioned will probably kill most of the young that are hit, and if the application is repeated two or three times the numbers of the pest will be considerably lessened. Two or three sprayings are recommended at first to clean the trees, and then only one spraying annually thereafter. The same spray is recommended by Dr. Savastano with good results against *Aspidiotus hederae* and *Lepidosaphes beckii*.

The spray as used in the groves of Sicily is applied by means of a hand pump mounted on a wheelbarrow truck. This is about as large an outfit as may be used under the trees. No horses ever enter most of the Italian citrus groves, all the work of cultivation, etc., being done by hand labor. From the writer's observations a very great improvement resulted from the applications of lime-sulphur. Not all the insects were, of course, killed, but the numbers were greatly lessened, and a marked improvement in the trees resulted. This spray has the advantage, also, of checking many of the possible fungous troubles as well as stimulating the growth of the tree.

Aside from the control measures mentioned, Dr. G. Brigante[2] states that the worm, *Prays citri*, of the blossoms may, if necessary, be handled by a 1 per cent solution of lead arsenate. But poison sprays are in bad repute in Italy.[3] Prof. Ampola and Dr.

[1] Savastano, L. Le conclusioni pratiche per la poltiglia solfocalcica (formo a della Stazione). R. Staz. Sper. di Agr. e fruitti coltura, Acireale, Sicily. Bol. no. 11, 11 p., April, 1913.

[2] La coltivazione degli agrumi in Provincia di Salerno, Dott. G. Brigante, Direttore Cattedra Ambulante di Agricoltura per la Provincia di Salerno, 1912.

[3] Insetti damnosi e composti arsenicali, Teodosio De Stefani, Gazetta Commerciale, Palermo, p. 5–10, 1912.

Tomasi, of the Station Chimico-Agraria Sperimentale di Roma, strongly recommended the prohibition of arsenicals for general agricultural purposes. They conclude that their use is injurious to all sorts of plants and animals, but the most potent of their reasons is that the farmers, instead of poisoning their insect foes, might destroy human life. In addition to these control measures practiced in Spain and Italy, a small amount of spraying has been done around Jaffa in Palestine for a species of thrips on the orange. From the little evidence of thrips work that was seen at Jaffa the species occurring there is not *Euthrips citri*, as was supposed.

MEDITERRANEAN CITRUS FRUIT INSECTS THAT DO NOT OCCUR IN THE UNITED STATES AND THE POSSIBILITY OF THEIR INTRODUCTION.

Of the citrus insects discussed in the foregoing pages, two do not occur in the United States, namely, *Ceratitis capitata* and *Prays citri*. Two others, *Chrysomphalus dictyospermi* and *Parlatoria zizyphus*, while occurring in the United States, do not appear to be established as important pests, as is the case in the Mediterranean region. Concerning the distribution of these two scales, Mr. C. L. Marlatt, under date of March 5, 1914, writes as follows:

> *Chrysomphalus dictyospermi* is frequently found on palms and quite a number of other plants which are probably imported, and has a wide distribution in greenhouses. Out of doors it does not seem to thrive very well on this continent, and I think we have very few outdoor records of it, and these naturally from southern points. It has been so often brought into this country that its failure to establish a foothold in citrus orchards apparently indicates unfavorable conditions for this insect, but it is, of course, possible that this may have resulted, after all, from lack of favorable opportunity. *Parlatoria zizyphus*, as you know, is brought to this country all the time on Italian lemons, and has been found in the open market wherever these lemons are sold, including well-established citrus districts such as those of Florida and Louisiana.

In case these two scales did become established in our citrus groves our present control methods, at least fumigation, would handle them successfully. This fact, however, should be no excuse for not quarantining against them. On the other hand, the other two, *Ceratitis capitata* and *Prays citri*, would not only be serious pests but would not be controlled by any of our methods now in use for citrus trees. Ceratitis, moreover, is not limited as a pest to citrus fruits; indeed, citrus fruits are by no means its favorite food, but it attacks a long list of deciduous fruits. The scope of this paper has to do, however, chiefly with citrus fruits.

The first shipments of oranges are made from Spain as early as October, and a few of the mature fruits at this time may contain larvæ of Ceratitis. But with the approach of cold weather in November and December the fly disappears. The time when infested fruits might be received from Spain is at the beginning of the shipping sea-

son in October and November, and again during the final shipments, the last of June and first of July. The reason more infested oranges do not occur in Spain is not, as has been suggested, because the fruit is picked too green, but because practically all the fruit matures and is harvested at a season when the fly is not active or breeding. This applies to practically all semitropical countries where citrus fruits are grown commercially. Plenty of oranges were seen in Spain that were fully mature in March, but which were not harvested until May or June. The heavy shipments do not begin in Spain until November, and by May the season is virtually ended.

What has been said regarding oranges in Spain applies to all the Mediterranean citrus sections. Up to the middle of October in Palestine the oranges were still too green to be infested with Ceratitis. Even though the fly may be present and actually deposit eggs in the fruit, there is no danger of the larvæ developing if the fruit is immature. In spite of numerous punctures and eggs in the fruit which were seen in Sicily up to October 1 and in Palestine up to October 15, no larvæ succeeded in developing or getting beyond the egg cavity, but there perished.

The lemon is an unusual and rare host for Ceratitis, at least in the great lemon-producing section of Sicily. It was only very rarely, and, it must be admitted, more or less accidentally, and after much persistent searching, that lemons were found infested in Sicily. Out of numbers running into hundreds of thousands only 15 were found infested. And all of these infested lemons were so badly broken down by decay that they would not only be rejected for shipping, but, with three or four exceptions, would be rejected for the by-product factory. So far as one season's experience in Sicily warrants the conclusion, therefore, there is only the remotest possibility of the entrance of Ceratitis into this country through the importation of lemons from Italy.

In the case of most other fresh mature fruits, which are harvested between May and November, inclusive, and coming from the Mediterranean countries, the possibility of Ceratitis introduction can be removed only through a strict embargo against such fruits or a subjection to a rigid inspection.

THE OLIVE FLY.

Dacus oleae Rossi.

Since the olive is usually grown in the same countries as citrus trees, it may be pertinent in this place to mention the olive fly. This insect, *Dacus oleae*, is one of the most serious pests of the Mediterranean countries. In fact it is the opinion of the writer that it far outranks *Ceratitis capitata*. A heavy infestation of the olive fly has been seen in different places, but particularly in Sicily and southern

Italy. Most of the olives attacked fall to the ground before reaching maturity. In the case of the olive fly, mature fruit is not at all necessary for infestation. Because of the economical use made of all the inferior fruit in these countries—something we have yet to practice—infested olives are not a complete loss, for they are used for oil, most of which is used in the manufacture of soap. The striking difference in habits between the olive fly and the Mediterranean fruit-fly is that, with the former, pupation occurs within the fruit, instead of in the ground or otherwise out of the fruit as is the case with Ceratitis.

Infested olives may be distinguished by a circular area on the surface that is of a light gray color. Before entering the pupal stage the larva eats out a channel to the surface of the fruit, leaving only the thin epidermis. It is this, with the tissue eaten away below, that forms the characteristic gray area that indicates infestation. It is much the same as that made in the case of the pea and bean weevils. Having completed the burrow to the surface, the larva retreats a short distance and transforms to the pupa, enclosed in the characteristic puparium, that looks much like that of Ceratitis. Upon emerging the adult fly breaks through the epidermis, which has been left for protection, by means of its ptilinum.

Fortunately olives are not transported unless pickled, and thus the danger of introduction is not great. But a sharp lookout should be kept for any olives that might possibly be imported fresh from these countries, since the egg, larval, and pupal stages are all passed within the fruit.

THE MEDITERRANEAN CITRUS FRUIT INDUSTRY.[1]

SPAIN.

LOCATION.

The most important citrus section of Spain, where 90 per cent of the crop is produced, consists of a narrow strip, 10 or 15 miles wide and 150 miles long, extending from Denia in the Province of Alicante northward as far as Vinaroz in the Province of Castellon. This is the so-called "Valencia section," the city of Valencia being situated somewhere near the center of the strip. In this section are recognized two distinct districts, the "Ribera" and the "Plana." The "Ribera" lies to the south of Valencia and centers chiefly about the towns of Alcira and Carcagente. This district is more or less rolling and hilly and is separated from the sea, which is 15 or 20 miles distant, by hills and mountains. The "Plana" lies north of the City of Valencia and centers about the town of Burriana. This is a perfectly flat plain and borders directly on the sea. Around the

[1] In this account of the Mediterranean citrus industry only such phases are presented as are necessary to a better knowledge of the insects discussed in the earlier pages of this paper.

FIG. 1.—INTERIOR OF PACKING HOUSE AT ALCIRA, SPAIN. (ORIGINAL.)

FIG. 2.—THE RAILROAD PACKING HOUSE AT CARCAGENTE, SPAIN. (ORIGINAL.)

SORTING AND SHIPPING CITRUS FRUITS IN SPAIN.

FIG. 1.—HAULING ORANGES TO THE BOAT LANDING AT BURRIANA, SPAIN. (ORIGINAL.)

FIG. 2.—LOADING ORANGES IN SMALL BOATS TO BE TRANSPORTED TO STEAMER, BURRIANA, SPAIN. (ORIGINAL.)

ORANGES IN TRANSIT IN SPAIN.

city of Valencia itself in the "Heurte de Valencia" there are few oranges grown, excepting at Piaporto and Picaña and to the westward of these villages.

Going farther southward the next important orange section is at Murcia, and then at Malaga, with a few scattering groves between. In the Malaga section probably the most important center is at Alora, some distance back from the sea, and in a mountainous country. The next important section of Andalusian Spain is in the vicinity of Seville. Here, however, practically all of the crop is of the bitter variety and is shipped to Great Britain and made into marmalade.

METHODS OF HANDLING CROP.

The harvesting season in Spain extends from October to July, with the heaviest shipments occurring from November 15 to December 1. The oranges are picked in small baskets and from these are dumped into larger baskets along the roadside or edge of the grove, thence being carried, by means of carts, to the packing house. They are here spread on the floor to a depth of about 2 feet, the floor and sides for a couple of feet being first covered with a layer of rice straw. Women sit around the edge of these piles of fruit which, if infested with sooty-mold fungus, is rubbed first in wet and then in dry sawdust to remove the mold. Other women then sort out the fruit in three different sizes, entirely by sight, and also discard the culls. The fruit is then wrapped in paper by other women and packed in the boxes.

The three sizes of fruit are represented by the cases containing respectively 420, 714, and 1,064, and which weigh 165 pounds each, or about twice that of the American box. There is absolutely no machinery in a Spanish packing house, all the processes of handling, grading, washing, and box making being done by hand. The packing house itself is, therefore, simple, consisting of four walls and a roof, the earth forming the floor. (Pl. VII, fig. 1.) The appurtenances consist of the shipping cases, a good supply of shallow wicker baskets, and plenty of women to do the work. The time the fruit remains in the packing house depends largely on the departure of the steamer and varies from a day or two to more than a week.

After the fruit is packed in cases it is hauled, in carts, without springs, to the boat landing. Here the cases are unloaded along the shore and later placed in small boats and finally transferred to the steamer. At Burriana, the port of the "Plana" district, from which 2,000,000 cases are shipped annually, there is no pier, and the small boats are pulled up on the gravelly beach by oxen. (Pl. VIII, fig. 2.) The town, which is about 2 miles inland, and in which there are upwards of 100 packing houses, is not connected with the

beach by any railroad, and all of the 2,000,000 cases are hauled in carts each year, over a very bad road. (Pl. VIII, fig. 1.)

The foregoing description applies to the fruit sent by sea. A very small amount of the crop that is sent by railroad is also packed in boxes and handled in the way described. But nearly all of the fruit shipped by railroad is simply conveyed in loose carload lots. From 10,000 to 15,000 tons are exported from the Valencia district in this manner, while 400,000 to 450,000 tons are shipped by sea. Where the fruit is to be shipped by railroad in loose carload lots, the packing house occurs alongside the railroad. These packing houses are even simpler than those already described, for they consist simply of a roof, the sides being left open. The earth is graded up to the height of the floor of the car to facilitate the transfer of the fruit. The floor of this open-air packing house is covered with rice straw, as are also the floor and sides of the car. The cars are usually of the pattern of our stock cars, with lattice work on the sides to allow for plenty of ventilation. (Pl. VII, fig. 2.)

The oranges are brought from the field directly to the railroad packing house, where they are piled on the floor. Women here give the fruit the sawdust treatment, if needed, and the culls are discarded. It is now ready for the car, where it is carried in baskets and filled to the depth of a couple of feet. Such fruit goes mostly into France, or to other parts of Spain.

PRODUCTION AND EXPORT.

From figures kindly furnished by Mr. Claude I. Dawson, American consul at Valencia, the total production of oranges for the season 1912–13 amounted to nearly 7,000,000 cases of 165 pounds each. This amounts to about 38,500 California carloads or 45,117 Florida carloads. Of this amount 5,573,627 cases were shipped by sea, as follows:

	Cases.
Great Britain	2,253,076
Germany	1,374,829
Holland	501,645
Norway and Sweden	84,374
Austria-Hungary	18,110
Denmark	17,103
France	6,033
Russia	1,000

The overland shipments to France approximated 1,200,000 cases, and the remainder of the crop was consumed in Spain.

According to the figures of the United States Bureau of Statistics there were shipped into the United States from Spain in 1912, 9,000 pounds of oranges and lemons (not separately listed), valued at $204. The only records the writer was able to obtain in Spain of orange ship-

ments to the United States were of a few small shipments during the last two or three years from Seville. The use made of these shipments was not known, but was no doubt for the manufacture of marmalade, as is the case with all the bitter orange product of Seville. One hundred and fifty thousand cases are exported annually from Seville, mostly of the sour or bitter orange, and practically all are sent to Great Britain for the manufacture of marmalade.

ITALY.

LOCATION.

The important citrus fruit areas of Italy are on the Island of Sicily, in the Provinces of Calabria and Campania, and along the Riviera di Ponente and the Riviera Levante.

The most extensive section, particularly for lemons, is in Sicily. The area extends along practically the entire north and east coasts. There are, of course, breaks in this strip, as where the mountains extend abruptly to the sea, or where grapes largely occupy the territory, as at Milazzo, Carruba, and Riposta, or on the plain south of Catania, where various other crops are grown. The limits of this area are the Gulf of Castellammare on the north and Avola, below Syracuse, on the east coast. Even within these limits lemons do not occur solidly because of the irregularity of the land, lack of water, and unsuitable soil. Most of the lemons are grown in close proximity to the coast, but occasionally they extend inward for several miles, as at Monreale, Alcantara, and Floridia. Occasionally citrus trees will be found in the interior valleys, but here it is largely oranges, probably because of the greater likelihood of frost.

In the Province of Calabria there is a considerable area of citrus fruit along the coast from Reggio to Rosarno and farther northward and inland at Cantanzaro and Cosenza. The Campania section is situated principally along the coast from Salerno through Majori and Amalfi to Positano. Here the trees are grown on terraces (Pl. IX, fig. 1), formed on the very abrupt slopes extending upward from the sea. Unlike other sections, also, the trees are covered with trellis, on which, during the winter for protection against frost and wind, is placed straw and brush. The Riviera section consists of a narrow and much broken strip extending from Ventimiglia on the French border to Spezia.

METHODS OF HANDLING CROP.

Lemons in Sicily are harvested practically every month in the year, the heaviest shipments occurring in the spring and early summer, while the fewest shipments occur during the month of August. The number of pickings in any particular grove is from four to six. The lemons are broken from the tree by hand, leaving two or three inches

of stems with the fruit. These are placed in small baskets, supported in the tree or carried on the arm, and when filled are carried to the men who clip off the extra stem, leaving the usual button. In the case of *verdellis*, green lemons, during the summer, these are sometimes broken from the tree by means of a forked bamboo rod. This rod is long enough to reach to all parts of the tree from the ground, and the fruit is simply allowed to fall as it is twisted off. When asked about the effects of bruising by such a method, it was stated that the fall does not hurt the green fruit. Such a method is rapid, since the lemons are quickly twisted off and allowed to fall, and are picked up, usually by small boys, but it is not practiced by the best growers.

The fruit with the small buttons is placed in baskets and carried thus to the field packing house (Pl. X, fig. 3). Here it is roughly graded, and the culls are separated for consignment to the by-product factory. It is placed in the regular shipping boxes (Pl. X, figs. 1, 2), but thrown in loosely, with paper around the inside of the box. Sometimes with the better grades, and in the case of long hauls, each lemon is wrapped separately. In these shipping boxes the fruit is carried in carts to the town or exporter's packing house, where it is regraded, sorted, and packed back in the same boxes, when it is carried in carts to the lighter, and thence to the steamer for final shipment. (Pl. IX, fig. 2.)

The time the fruit remains in the field packing house may vary from 1 to 3 or 4 days, or longer; in the exporters' packing houses, from a day or two to a week or two. The average time of transit from Palermo to New York is 12 or 15 days. The time between the picking and the landing of the fruit in New York may thus range from 18 days to 30 or 40 days.

A large percentage of the fruit that is harvested during the spring and early summer is what is called in California tree-ripe fruit, while that harvested in midsummer and fall is mostly green fruit, or *verdellis*. *Verdellis*, of course, occur with the yellow fruit, and they are packed separately and so consigned. The large proportion of *verdellis* which occur in midsummer are artifically produced. During the previous summer water was withheld from the trees for about six weeks, and then two or three irrigations were applied in quick succession. This procedure causes the trees to throw out an unusual amount of blossoms which mature into fruit the following summer. This fact of a very large preponderance of green fruit during the summer and fall has an important practical bearing in connection with the possible infestation of the Mediterranean fruit-fly. It is during the summer and fall that the fly is most actively breeding. Very little yellow fruit appears before November, but from that time until the following July it is nearly all yellow fruit. No place was seen in Sicily where lemons are subjected to forced curing, as they are in California.

FIG. 1.—THE FAMOUS TERRACED LEMON GROVES ON THE AMALFI COAST OF ITALY. (ORIGINAL.)

FIG. 2.—LIGHTERS OF THE FELLUCA TYPE CARRYING LEMONS TO THE STEAMER, PALERMO.

LEMONS IN ITALY.

FIG. 1.—TRANSPORTING LEMONS IN THE HILLY SECTION OF SICILY, WHERE THE ROADS ARE POOR. (ORIGINAL.)

FIG. 2.—OPEN CARS (NO ROOFS) LOADED WITH BOXED LEMONS FOR TRANSPORTATION FROM THE SMALLER TOWNS TO THE SEAPORT, SICILY. (ORIGINAL.)

FIG. 3.—A "FIELD" PACKING HOUSE AND CART WITH BASKETS OF LEMONS FROM THE NEAR-BY GROVES, SICILY. (ORIGINAL.)

FIG. 4.—A FUMIGATING TENT, IN POSITION, SPAIN. MODELED AFTER THE OUTFITS ORIGINATING IN CALIFORNIA. (ORIGINAL.)

FIG. 5.—A LABORATORY AT PALERMO; THESE ARE THE PEPPER TREES. (ORIGINAL.)

TRANSPORTING LEMONS IN SICILY. FUMIGATION OF CITRUS TREES IN SPAIN.

PRODUCTION AND EXPORT.

The total acreage exclusively in citrus fruits in Italy in 1909, according to Powell,[1] was 108,400 acres, and 170,000 acres on which other crops were grown. A total of 85,252 acres were grown in Sicily, out of which 4,102 acres were in mixed cultivation; 13,890 acres entirely in citrus fruits were in the Province of Calabria and 9,385 acres in the Province of Campania.

The total production of lemons in Italy, including that converted into by-products and that used in home consumption, in 1911 was 1,192,701,829 pounds, or 47,785 of our carloads, basing this calculation on the size of the California box of lemons, which is estimated to weigh 80 pounds, and on the number of these boxes, namely, 312, loaded in the California cars. The exports of lemons alone were 570,306,431 pounds, or 22,841 of our carloads. The United States during the past 10 years has received about 35 per cent of the total exports. In 1910 the distribution among the principal countries was as follows:

	Per cent.
United States	31.5
Austria Hungary	19.8
United Kingdom	19.5
Germany	11.3
Russia	8

In 1911, 96 per cent of our Italian lemons came from Sicily, of which 86.4 per cent were from Palermo, 9.8 per cent from Messina, and 3.8 per cent from Naples, including the Amalfi Coast district. The Italian box contains about 73 pounds of fruit, which is chiefly in 300 and 360 per box sizes. About half of the total imports arrive here in May, June, and July; 85 to 90 per cent are received in New York, about 5 per cent in Boston, and smaller quantities in New Orleans, Philadelphia, Baltimore, and a few other places.

According to the United States Bureau of Statistics, the total imports of lemons from Italy in 1912 were 145,275,122 pounds, valued at $3,359,115; of oranges, 401,161 pounds, valued at $9,319.

FRANCE AND ALGERIA.

No extended observations were made in the citrus sections of France and Algeria. In France the area appears to be limited to a short and much broken strip along the Mediterranean Coast, the French Riviera, extending from Cannes to Menton on the Italian border. In northern Africa the most extensive production of oranges is in Algeria. But the output there is not large, for Algeria and France together do not produce nearly enough for home consumption in France, as evidenced by the large imports from Spain.

[1] The figures here given are from Powell, Harold C., and Wallschlaeger, F. O. The Italian lemon industry. *In* Citrus protective league of California, Bul. 10, 58 p., Jan., 1913.

PALESTINE AND EGYPT.

In the eastern Mediterranean countries the most important citrus-producing sections are in Palestine and Syria. The largest and most important district is in the neighborhood of Jaffa, the home of the well-known Jaffa orange; 1,600,000 boxes (same size as ours) were shipped from Jaffa alone last year. Most of these were sent to the Liverpool market, with smaller amounts, and of poorer grade, to Turkey, Egypt, and other near-by countries. In all the earlier plantings around Jaffa the trees are very close together—9 to 12 feet. In the later plantings, however, and particularly in the Jewish colonies, where all the best groves are located, they are from 14 to 18 feet apart. Irrigation is by the basin system, and the source is from wells, from which the water is pumped, in the Jewish colonies, by gasoline engines. On account of the sandy soil largely, water is applied every 8 or 10 days. The methods of packing and shipping are much the same as in Italy and Spain. Mr. A. Bril, a prominent grower and manager of the Jewish colonies around Jaffa, who visited the United States last year, has adopted California methods, and the fruit so handled and packed brought 25 cents a box more than other fruit.

Aside from Jaffa there is another small section around Acre, farther to the north and also along the Palestine coast. Still farther north in Syria there are citrus sections at Saida and Tripoli, there being a considerable lemon acreage in the latter place.

In Egypt citrus culture is limited to scattering groves, most of which are poorly cared for, and from which the production is limited to local consumption.

METEOROLOGICAL DATA FOR VALENCIA, SPAIN, AND PALERMO, ITALY.

Since meteorological conditions may have a very great influence on many insects, as has been specifically pointed out in the case of the black scale, the following data are given for the most important orange and lemon centers, respectively, of the Mediterranean countries.

It will be noted from the following tables that, excepting 1910, higher temperatures prevailed at Palermo than at Valencia. High temperatures at Palermo, moreover, are accompanied by extreme dryness, and usually much wind. This combination of heat and very great evaporation is sufficient to account for the scarcity of the black scale in Sicily, as compared with Valencia, Spain. The writer is also inclined to attribute the scarcity of the purple scale in Sicily to this same cause. In the United States the purple scale thrives best in Florida and the coast counties of southern California. While rather high temperatures prevail in Florida, there is also much humidity. The distribution of the purple scale at present in the United States is,

therefore, limited to sections of more or less moisture. In this respect it is like the black scale, but the black scale does not thrive so well in high temperatures, even if accompanied by much moisture. The purple scale does not yet occur in the interior counties of southern California or in the great valleys of that State. Of course this may be due to the close quarantine that has prevailed in those sections in recent years against the purple scale. But judging entirely from its present distribution, the purple scale appears to be restricted to regions of more or less moisture, or at least to those in which the combination of high temperatures and low humidity does not prevail.

Temperatures at Valencia, Spain, and Palermo, Italy, January, 1910, to August, 1913, inclusive.[1]

	Valencia, Spain.			Palermo, Italy.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
1910.	°F.	°F.	°F.	°F.	°F.	°F.
January	72	37	50	69	35	50
February	79	33	54	71	35	50
March	70	35	52	69	35	52
April	83	32	58	87	39	58
May	84	40	62	79	44	61
June	95	49	70	86	52	68
July	102	52	74	91	55	72
August	99	57	74	91	58	74
September	84	53	62	90	53	69
October	81	43	65	94	50	68
November	79	37	58	87	37	58
December	72	34	53	77	38	55
1911.						
January	66	35	46	64	31	48
February	81	35	51	72	30	49
March	70	33	53	82	34	55
April	88	35	56	80	39	56
May	83	42	63	80	47	62
June	86	53	69	86	52	70
July	98	59	69	92	52	76
August	95	60	77	93	64	79
September	96	55	73	105	56	74
October	80	42	64	93	51	69
November	75	35	55	80	45	62
December	71	33	53	70	38	55
1912.						
January	71	35	51	70	35	52
February	77	33	55	71	37	55
March	84	37	58	73	40	57
April	75	37	57	79	41	57
May	94	43	65	93	45	64
June	86	50	68	87	54	70
July	97	59	74	106	59	77
August	100	48	74	92	57	75
September	96	52	68	83	51	66
October	86	45	63	79	50	64
November	79	33	55	74	42	54
December	70	36	50	68	40	52
1913.						
January				65	37	52
February				67	33	50
March				84	36	54
April				79	40	59
May				85	47	64
June				88	53	70
July				95	56	74
August				107	57	75

[1] In converting centigrade into Fahrenheit, fractions have been discarded.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1914

ADDITIONAL COPIES

OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
15 CENTS PER COPY

▽